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Reports
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COMPARATIVE ECOLOGY OF MONTANE SNAKES IN BURNED AND UNBURNED MADREAN WOODLAND

Prepared by Kirk Setser

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Work Plan - 2005

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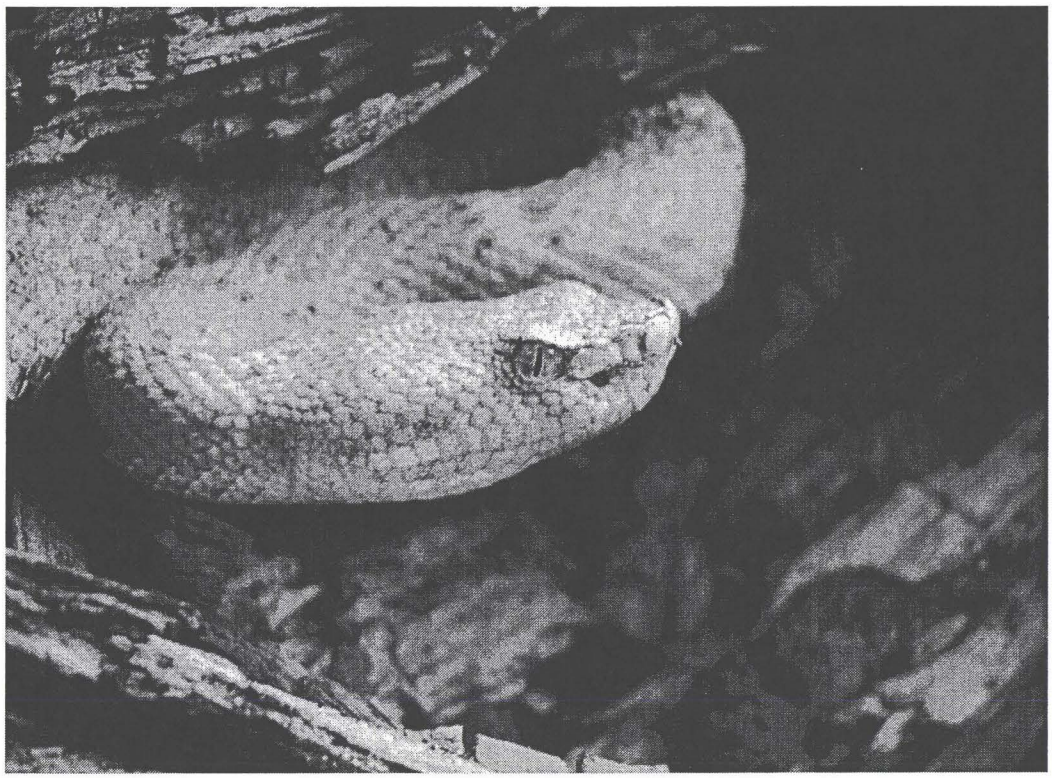
Project Title: Comparative ecology of montane snakes in burned and unburned Madrean woodland



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Introduction

Madrean pine-oak woodlands have undergone extensive change over the last 150 years, and fire suppression and increased grazing have greatly decreased fire frequency. To reduce fuel loads, decrease the chance of catastrophic fire, and increase ecosystem health in the Peloncillo Mountains, the Coronado National Forest plans to reintroduce a natural fire regime in that mountain range. However, concerns about the impacts of high intensity prescribed burns have delayed implementation of the Peloncillo Programmatic Fire Plan. In particular, additional information on the effect of high intensity, warm-season burns on the federally threatened New Mexico Ridgenose Rattlesnake (*Crotalus willardi obscurus*), and two sympatric taxa, the Rock Rattlesnake (*Crotalus lepidus*) and the Sonoran Mountain Kingsnake (*Lampropeltis pyromelana*) will be of use in evaluating the ecological impact of fire in the Peloncillo Mountains. To gather information concerning the effects of fire on *C. willardi*, the Forest Service and the University of Notre Dame developed the joint agreement, **Comparative Ecology of Montane Snakes in Burned and Unburned Madrean Woodlands**.

The overall purpose of this agreement is to conduct long-term research on *C. willardi*, *C. lepidus*, and *L. pyromelana* in burned and unburned Madrean woodland. In 2002, in collaboration with the Forest Service and Matt Goode of the University of Arizona, we identified suitable sites for long-term studies of *C. willardi* in the Sierra San Luis in Sonora and Chihuahua, México. In 2003, we initiated fieldwork in the Sierra San Luis to fulfill specific objectives considered important in the evaluation of fire impacts on *C. willardi*. In 2004, these objectives were modified to reflect the difficulties encountered with initial techniques, and to take advantage of research opportunities revealed during fieldwork in 2003.

Original objectives

1) Initiate radio-telemetry of *Crotalus willardi* in the Sierra San Luis
2) Collect natural history data on *Crotalus willardi* and associated snakes
3) Collect life history data on *Crotalus willardi* and associated snakes

Updated objectives

1) Evaluate effectiveness of radio-telemetry on *Crotalus willardi*
2) Initiate study at an additional site in the Sierra Pan Duro

Methods

Study sites

We initiated field work at two sites in the northern Sierra San Luis in 2003. In 2004 we added a third study site further to the south in the Sierra Pan Duro portion of the greater Sierra San Luis complex (Figure 1). Study sites in the northern Sierra San Luis include a north-west facing canyon (Study Canyon) burned in an intense 1989 wildfire and an adjacent, largely unburned, north facing canyon (Cañon San Luis). The study site in the Sierra Pan Duro (Rancho Pan Duro) incorporates portions of the western fork of Cajon Bonito, and represents a lower elevation, riparian site that likely differs from northern sites in productivity and historic fire frequency.

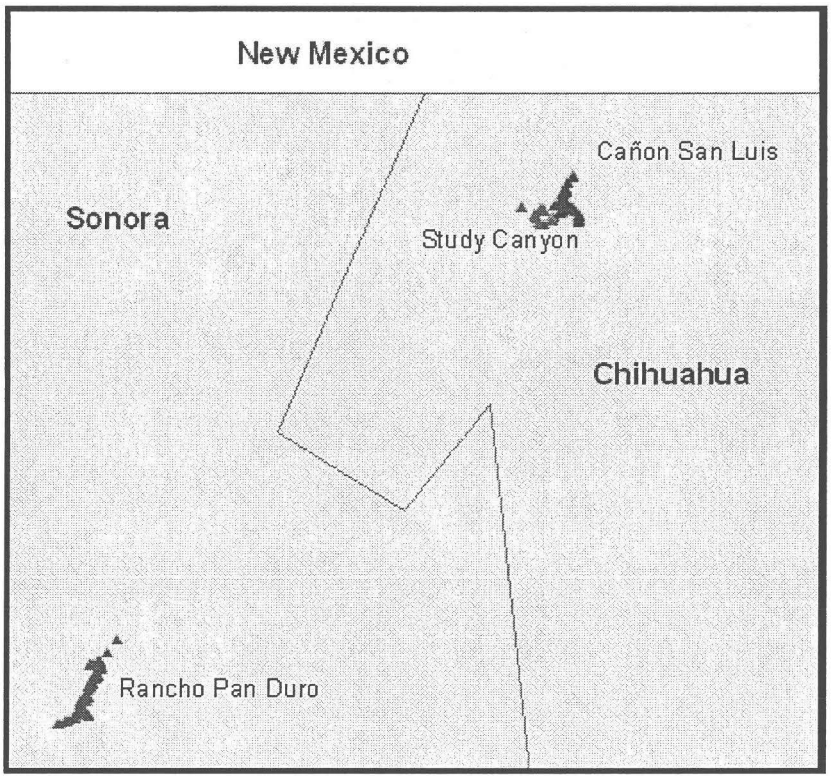

Figure 1. Relative locations of study sites in Sonora and Chihuahua, Mexico.

Study Canyon (Figure 2) runs from an elevation of approximately 1800-2175 m. Within this area, we concentrated most of our survey efforts between elevations of approximately 1850-2150 m. Following a 1989 wildfire, Study Canyon is dominated by oak (*Quercus*) and manzanita (*Arctostaphylos*) woodlands and chaparral. Open grassy areas predominate on lower south and west facing slopes.

Portions of Cañon San Luis (Figure 3) south of Mexican Highway 2 run from an elevation of approximately 1775-2125 m. Along the canyon bottom and at upper elevations, Cañon San Luis woodlands and sparse forests are dominated by oaks and Arizona cypress (*Cupressus arizonica*) and interspersed with

occasional pines (*Pinus engelmannii, P. leiophylla, P. cembroides*), and Douglas fir (*Psuedotsuga menziesii*). South and west facing slopes, as well as lower canyon slopes, include mixtures of chaparral, savanna and grassy habitats. Upper elevations along the southeastern edge of Cañon San Luis were burned in 1989 by fire spilling over from adjacent Study Canyon. However, the majority of the canyon has not experienced recent intense fire. We concentrated our surveys at elevations between approximately 1825-2075 m as few snakes were encountered at lower elevations.

We surveyed portions of Rancho Pan Duro (Figure 4) between approximately 1650-1775 m, confining surveys to the relatively mesic, riparian habitats within Cajon Bonito. This riparian community includes maples (*Acer*), oaks, pines, Arizona cypress, Douglas fir, and Arizona sycamore (*Platanus wrightii*). We observed no evidence of widespread wildfire within the Cajon Bonito riparian community; however, adjacent mesa woodlands stretching south of Cajon Bonito have been burned by recent wildfires.

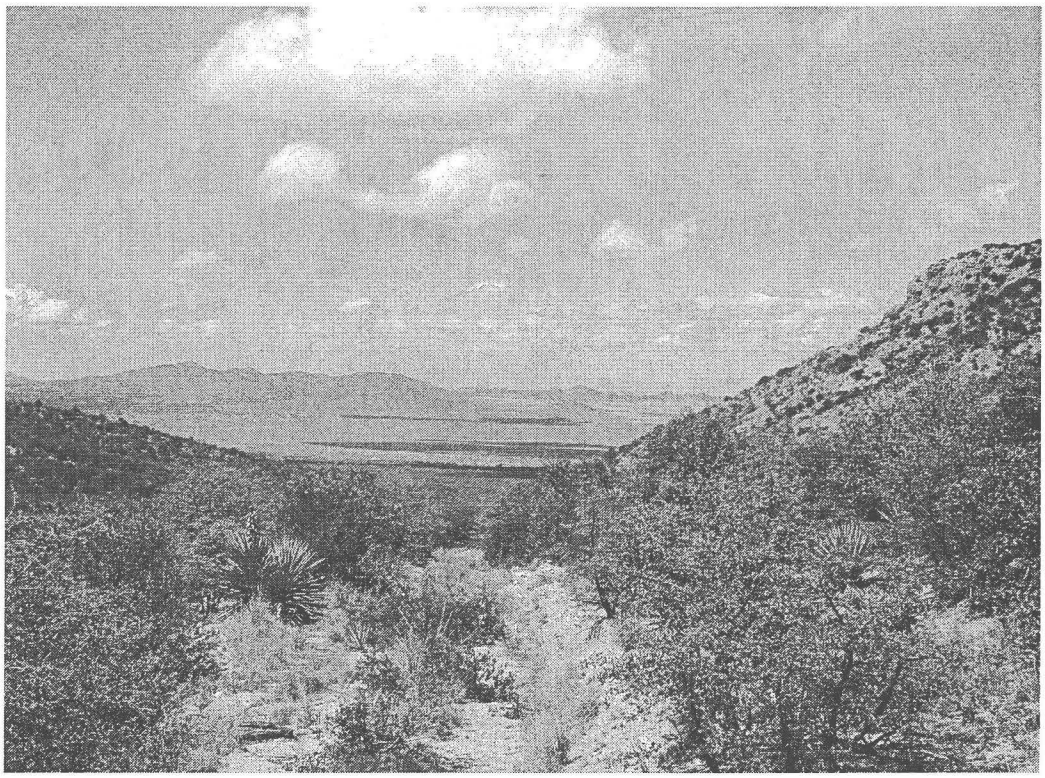

Figure 2. View from Study Canyon looking west across the Animas Valley.

Figure 3. Middle elevation oak woodland in Cañon San Luis.

Figure 4. Cajon Bonito riparian forest on Rancho Pan Duro.

Field methodology

We installed four weather stations in late June of 2003. These stations consisted of paired assemblies of heavy-duty plastic rain gauges and HOBO temperature and humidity sensors mounted on steel poles at a height of one meter. We placed two stations each in Study Canyon and Cañon San Luis at elevations of 1800 m and 1900 m. Throughout 2003 we experienced persistent problems with bears disturbing and sometimes damaging rain gauges. All rain gauges were damaged beyond repair by November 2003, and we chose not to replace them because we expected bear disturbances would continue as long as rain gauges remained. After removal of rain gauges, bears seldom disturbed the remaining HOBO sensors in 2004.

We initiated snake searches in late July of 2003 after receiving required permits from the Mexican government. We searched for *C. willardi* and associated snakes in Study Canyon and Cañon San Luis during July, August, September, October, and November of 2003. In 2004, we restricted our search efforts to the more productive months of August, September, and October. In 2003, we briefly surveyed nearby sites, including Rancho Pan Duro. In our second year, we greatly increased our search efforts at Rancho Pan Duro, spending approximately equal time at all three sites in 2004.

When we encountered *C. willardi* and other snakes, we captured them and recorded their position as well as the elevation, time, and date using a hand held GPS (Garmin Geko 301). We later measured, weighed, marked with a PIT tag, and drew blood from snakes prior to release at the point of capture. In addition, we palpated all snakes for feces and female snakes to determine reproductive condition. In 2003 we implanted radio transmitters into 20 *C. willardi* and 12 *L. pyromelana*.

Although we wished to continue monitoring these snakes in 2004, due to transmitter failure and death of snakes carrying transmitters, we were able to reencounter only five *C. willardi* and six *L. pyromelana* in the spring of 2004. At this time, we became concerned about the high proportion of snake deaths and the poor condition of some snakes carrying transmitters. We continued to monitor the condition of snakes still carrying transmitters, and in August 2004, decided to remove all remaining transmitters from snakes.

We recorded positions, dates, times, elevations and a series of habitat and microhabitat variables from radio-telemetry positions. These variables included: 1) habitat type, 2) microhabitat type, 3) substrate, 4) snake visibility, 5) canopy cover, and 6) canopy height.

In 2004 we implanted miniature temperature recording data loggers (iButton thermochrons) programmed to record snake core body temperatures every four hours over a ten month period in 17 *C. willardi*. We confined thermochron

implants to snakes in excess of 80 g. We hope to reencounter many of these snakes in 2005 in order to remove thermochrons and recover temperature data. We will use these data to compare thermal differences between snakes inhabiting different sites.

Results and Discussion

We present preliminary results from research efforts in 2003 and 2004. Because these data are incomplete, we concentrate on results which allow us to better focus research in coming years and present only highlights from data collected. Future treatments will include more detailed statistical analyses and expanded discussions of the implications of results. We discuss current results in two sections: 1) demographic and natural history results, and 2) results from radio-telemetry efforts.

Demography

We found many more *C. willardi* in 2004 than in 2003 (Figure 5). Many factors likely contributed to this result. In 2003 the Sierra San Luis experienced an abnormally dry year relative to 2004. Snakes likely were more active, and hence more easily encountered because of this climatic difference. In addition, we improved our ability to target productive time periods and areas in 2004. For example, we searched more person-days in September and October and fewer in earlier months. We also shifted more effort to higher elevation areas of Cañon San Luis and "Study Canyon", where we encountered more snakes than in lower elevations. Finally, we spent more time at Rancho Pan Duro, the most productive site.

Increased numbers of *C. willardi* was not an artifact of increased search effort. We searched less time in 2004 (202 person days) than in 2003 (260 person days). We required considerably less effort to find a snake in 2004 (Figure 6). In addition to differences between years, we noted differences in encounter rates between sites. We found more snakes in less time at Pan Duro than at either of the two northern sites, however we also recorded greater search effort per snake in the burned Study Canyon than in the unburned Cañon San Luis. The relative difference between Study Canyon and Cañon San Luis remained consistent in both years, despite dramatic annual changes in search effort required. At all sites, search effort required per snake in 2004 compared favorably with data from previous research in other mountain ranges (ca. 3.5 pd/snake in the Animas Mountains, ca. 34.9 pd/snake in the Peloncillo Mountains; A. Holycross pers. comm.). Encounter rates recorded by Holycross and associates from a site in the southwestern Sierra San Luis were roughly equivalent (1.4 pd/snake; A. Holycross pers. comm.) to encounter rates we recorded at our nearest site, Rancho Pan Duro.

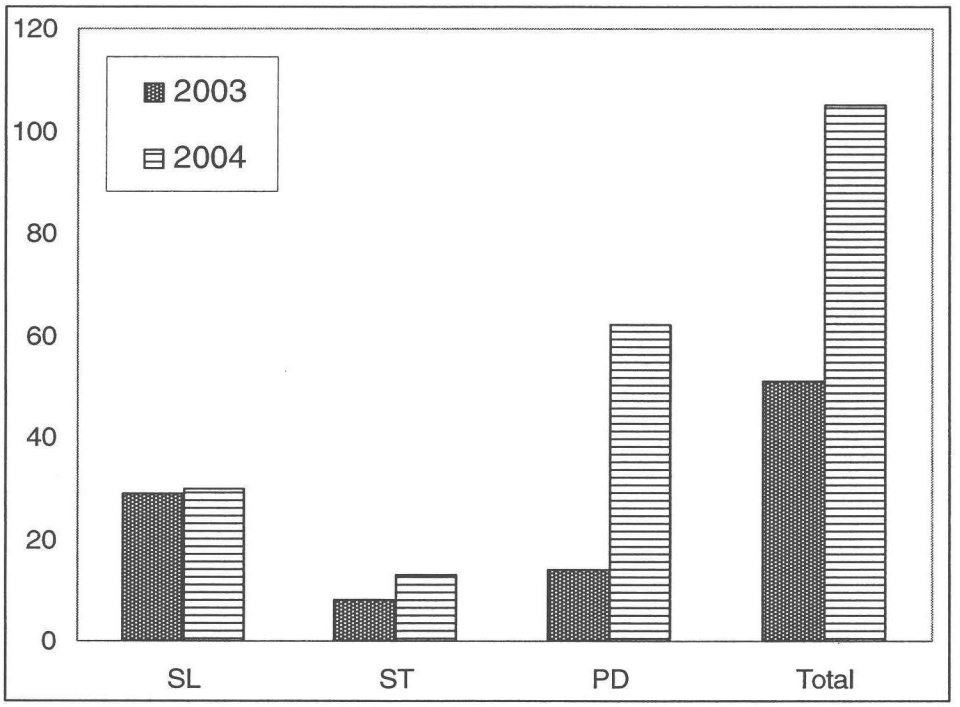

Figure 5. Numbers of individual *Crotalus willardi* encountered in 2003 and 2004 in Cañon San Luis (SL), Study Canyon (ST) and Rancho Pan Duro (PD). These numbers do not include recaptures.

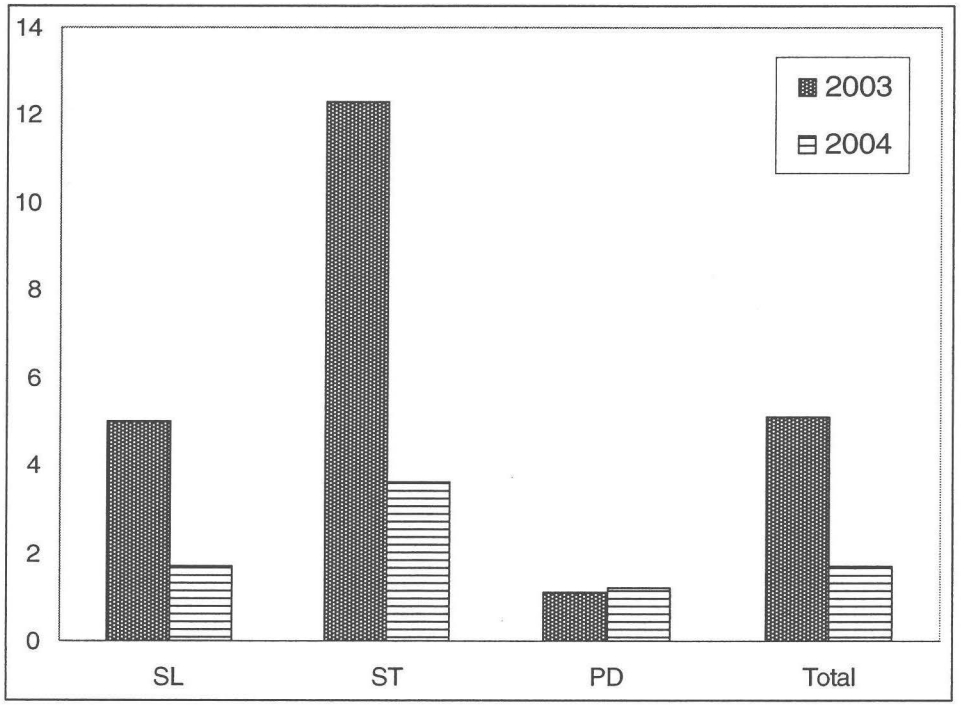

Figure 6. Search effort required to find each new individual *Crotalus willardi* in 2003 and 2004 in Cañon San Luis (SL), Study Canyon (ST) and Rancho Pan Duro (PD). Data are presented as number of person days per snake encountered.

In 2004, we recaptured 15 of 43 *C. willardi* marked in 2003 (35%), and an even higher percentage within Study Canyon (4 of 7, 57%). This is important as it provides us reason to believe we are likely to reencounter marked snakes, which will allow us to gather data on growth and age, estimate demographic characters (including population size and survivability), and recover data from snakes implanted with thermochrons. We will also be afforded the chance to recover failed transmitters from snakes still carrying these units.

Our preliminary investigations of *C. willardi* population structure indicate differences among sites. Larger size classes were disproportionately frequent in the Study Canyon population (Figure 7). In contrast, we encountered numerous juvenile snakes in Rancho Pan Duro. We know that females from Study Canyon are reproducing, because we encountered several females containing ova. Instead, we attribute the paucity of juvenile snakes in Study Canyon to one or more of the following: 1) rapid growth to adult size, 2) high juvenile mortality, or 3) occupancy by juveniles of difficult to search habitats or microhabitats.

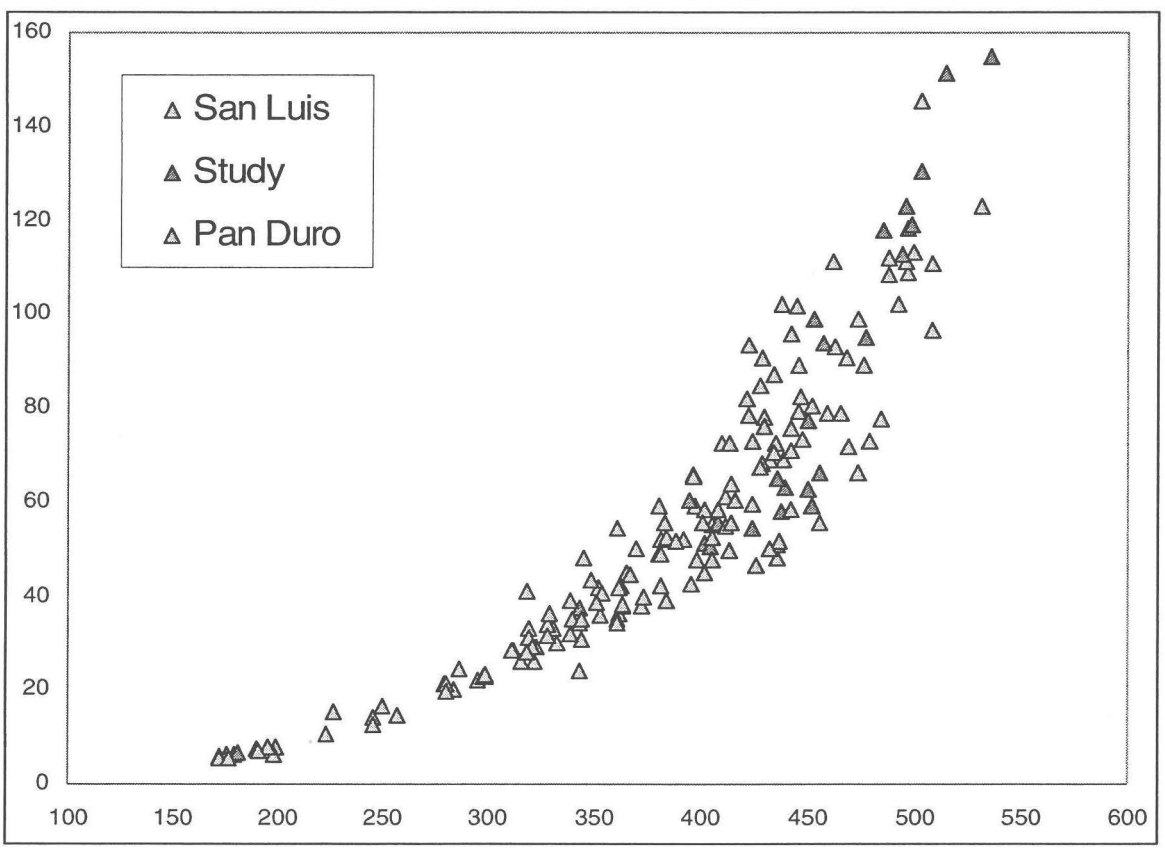

Figure 7. Scatter plot of *Crotalus willardi* size (mass in grams vs SVL in mm) in Cañon San Luis, Study Canyon and Rancho Pan Duro. Data include animals marked in 2003 and recaptured in 2004.

We collected over 70 fecal samples from *C. willardi* in 2003 and 2004. Preliminary data indicate some dietary differences among snake populations at different sites. Significantly, we discovered a higher than expected proportion of birds in the diet. We are currently collaborating with Dr. Heacker-Skeans at the Smithsonian National Museum of Natural History to identify feathers in fecal samples.

We documented all amphibian and reptile species encountered. We observed the greatest number of species in Rancho Pan Duro, and the fewest in Study Canyon (Table 1). Given the secretive nature of most herpetofauna, it is likely that we will continue to encounter new species at all three sites.

Table 1. Species observed in 2003 and 2004 in Cañon San Luis, Study Canyon, and Rancho Pan Duro. Numbers in parentheses indicate the total number of individuals captured in both years for selected species.

	San Luis	**Study**	**Pan Duro**
Amphibians			
Ambystoma rosaceum			X
Bufo alvarius			X
Bufo punctatus			X
Hyla arenicolor	X		X
Lizards			
Cnemidophorus spp.	X	X	X
Elgaria kingii	X	X	X
Eumeces callicephalus			X
Holbrookia spp.		X	
Phrynosoma hernandesi	X	X	
Sceloporus clarkii	X	X	X
Sceloporus grammicus	X	X	X
Sceloporus jarrovii	X	X	X
Sceloporus virgatus	X	X	X
Urosaurus ornatus	X	X	X
Snakes			
Crotalus lepidus	X (5)	X (3)	X (7)
Crotalus molossus	X	X	X
Crotalus willardi	**X (59)**	**X (21)**	**X (76)**
Lampropeltis pyromelana	X (14)	X (8)	X (6)
Masticophis bilineatus	X	X	X
Pituophis catenifer	X	X	X
Salvadora grahamiae		X	X
Tantilla wilcoxi	X		
Thamnophis cyrtopsis	X		X
Trimorphodon biscutatus	X		
Total Species	18	16	20

Radio-telemetry

Our initial objectives included large scale radio-telemetry efforts with *C. willardi*. We planned to follow a large sample size of snakes in order to gather data on habitat use and movement patterns, as well as to be able to follow a group of snakes over a period of years in order to gather data on growth, fecundity, and mortality. Unfortunately, data from our first two years indicated that radio-telemetry adversely impacts *C. willardi*. We observed one death which we attributed to transmitter implantation surgery, as well as two additional deaths which may have resulted from radio-telemetry activities. In addition, snakes carrying transmitters lost weight (Figure 8), and some snakes appeared to be in poor condition. Finally, we experienced numerous transmitter failures, causing us to prematurely lose track of snakes implanted with transmitters. Due to these problems, we concluded that continuing with radio-telemetry activities was not justified. In addition, we felt that growth, fecundity, and mortality rates would likely be impacted by radio-telemetry activities, making these data suspect should we continue to use this technique. Due to these considerations, we discontinued most radio-telemetry in May 2004, and all radio-telemetry in August 2004.

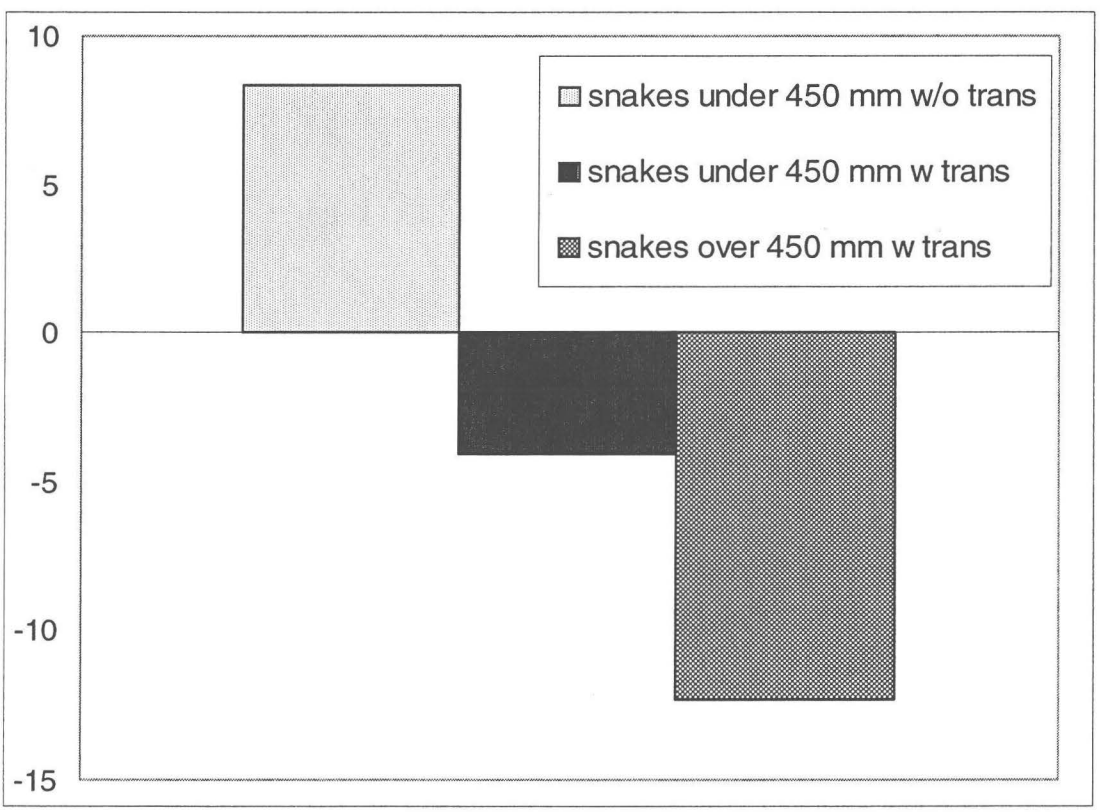

Figure 8. Weight loss in grams of *Crotalus willardi* carrying transmitters between 2003 and 2004. Data presented include snakes not carrying transmitters (N = 6), smaller snakes carrying transmitters (N = 4) and larger snakes carrying transmitters (N = 6).

Table 2. Movement patterns and percentage of telemetry positions in different habitat types from *Crotalus willardi* and *Lampropeltis pyromelana* in in Cañon San Luis and Study Canyon in 2003. Data from all individuals within groups were pooled due to limited sample sizes. Sample sizes given represent the number of individuals within a group (movement patterns), and the total pooled number of positions collected (habitat type).

movement patterns				
	mean distance moved (m)	max distance moved (m)	MCP area (ha)	
San Luis *C. willardi* (N = 9)	26	66	0.27	
Study *C. willardi* (N = 4)	15	44	0.29	
San Luis *L. pyromelana* (N = 10)	44	122	0.31	
Study *L. pyromelana* (N = 2)	20	73	0.23	
habitat type				
	open	chaparral	woodland	riparian
San Luis *C. willardi* (N = 82)	43 %	22 %	23 %	12 %
Study *C. willardi* (N = 34)	26 %	50 %	6 %	18 %
San Luis *L. pyromelana* (N = 77)	12 %	21 %	18 %	49 %
Study *L. pyromelana* (N = 21)	-	-	29 %	71 %

Table 3. Summary statistics of percentage canopy cover and canopy height of radio-telemetry positions of *Crotalus willardi* and *Lampropeltis pyromelana* in Cañon San Luis and Study Canyon in 2003. Data from all individuals within groups were pooled due to limited sample sizes. Sample sizes given represent the total number of positions collected.

percentage canopy cover				
	mean	SD	min	max
San Luis *C. willardi* (N = 72)	30 %	33 %	-	95 %
Study *C. willardi* (N = 24)	11 %	21 %	-	85 %
San Luis *L. pyromelana* (N = 61)	34 %	27 %	-	95 %
Study *L. pyromelana* (N = 19)	15 %	24 %	-	85 %
canopy height				
	mean (m)	SD (m)	min (m)	max (m)
San Luis C. willardi (N = 48)	3.8	3.8	0	18
Study C. willardi (N = 8)	1.7	0.7	1	3
San Luis L. pyromelana (N = 50)	6.2	4.5	1	21
Study L. pyromelana (N = 9)	2.3	1.4	1	5

Although severely limited in sample size, radio-telemetry data collected in 2003 indicated some differences between snakes in Cañon San Luis and Study Canyon. We did not detect any differences in movement patterns (Table 2), but did note differences in habitat type, percentage of canopy cover, and canopy height (Tables 2 and 3). These differences may merely reflect the types of habitats and canopies available to snakes in each canyon, and as such should be considered differences in habitat use, rather than habitat preferences. We

also present equivalent data for *L. pyromelana* (Tables 2 and 3). *Lampropeltis pyromelana* selected more riparian and wooded sites than did *C. willardi*, indicating that *C. willardi* were not seeking maximum use of these limited habitats in either canyon. Due to telemetry problems, we again caution that these data are of limited value. We hope to conduct more robust habitat analyses in the future using snake capture positions.

Conclusions and 2005 Workplan

We consider results to date to be mixed. We experienced poor capture rates early in 2003, at least in part due to severe drought in the Sierra San Luis. In addition, we were forced to discontinue plans to gather data using radio-telemetry. However, we had higher than expected capture rates in 2004, and we marked large numbers of *C. willardi*. If current encounter rates are sustained in future years, we will mark a larger population of snakes than has been possible in research projects in other mountains, and provide the basis for robust population analyses. We also experienced high recapture rates. This fortuitous result, at least in part, alleviates concerns raised due to failure of radio-telemetry techniques. In place of radio-telemetry, we will be able to use mark-recapture based data to estimate population sizes, mortality rates, and to examine population structure in burned and unburned areas.

In 2004, we initiated work at Rancho Pan Duro, where we had high encounter rates. Rancho Pan Duro is an important addition to the research project as it is the only low elevation *C. willardi obscurus* research site outside of the Peloncillo Mountains. We hope that data from this low elevation population will help us make comparisons between *C. willardi* populations in the Sierra San Luis and Sierra Pan Duro, and populations inhabiting the Peloncillo Mountains.

We propose that this research agreement be continued in 2005 in order to take advantage of the large population of marked snakes that we have established. We propose that our research objectives be modified to reflect the change in proposed research techniques as follows:

Future objectives

1) Collect natural history data on *Crotalus willardi* and associated snakes
2) Collect life history data on *Crotalus willardi* and associated snakes
3) Continue mark-recapture efforts at existing sites in the Sierra San Luis and Sierra Pan Duro
4) Initiate habitat analyses based on snake capture locations

We also recommend that this research be continued, at minimum, through 2006, and preferably through 2007. The value of mark-recapture data will continue to increase each year as the population of marked snakes expands and the number

of mark and recapture periods increase. In addition, we will be able to examine differences in use of burned and unburned habitats over a longer period of time, and increase chances that a naturally occurring wildfire will occur in our area.

Finally, we recommend that this agreement be continued through the existing partnership between the Forest Service and the University of Arizona rather than the University of Notre Dame. Matt Goode of the University of Arizona (formerly principal investigator on the project in 2002) was involved in the planning stages of this project, and continues to work on related projects focusing on *C. willardi.* Additionally, Matt has experience directing mark-recapture efforts with montane rattlesnakes. We feel that this research will benefit from his leadership in 2005 and beyond. This will also ensure that results are communicated to interested stakeholders, including the Malpai Borderlands Group (MBG) in Matt's role as science advisor to the MBG.

Proposed 2005 budget

Personnel	**Funds Requested**
PI (8 weeks @ $1100/week)	8,800
Graduate Student (12 weeks @ $400/week)	4,800
Field Technician (8 weeks @ 400/week)	3,200
5 Field Assistants (5 x 6 weeks @ $250/week ea.)	7,500
Living Expenses	
Food, supplies (7 people x 6 weeks x $100/week)	3,200
Housing (8 weeks in Agua Prieta)	1,000
Mileage	
10,000 miles @ $0.385/mile	3,850
Equipment and Supplies	
PIT tags (200 x $5)	1,000
Miscellaneous (tongs, gloves, photocopies, etc.)	1,500
Total	**$34,850**

Products

A note, based in part on observations recorded during this study, was submitted and accepted in 2004 and will appear in 2005 in the journal Herpertological Review. We plan to submit a minimum of two additional notes in coming months.

Acknowledgements

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